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Changing Ocean Conditions Affect Quality of Prey for Atlantic Salmon, Other Species

Researchers have found that changes in ocean conditions in the Northwest Atlantic during the past 40 years have altered the food web, changing the quantity and quality of important prey species. These food-web changes are thought to have influenced the survival and abundance of Atlantic salmon and many other ecologically, commercially, and culturally important species.

“Salmon are a good barometer of what is happening in the marine ecosystem,” said Mark Renkawitz, a salmon researcher at NOAA’s Northeast Fisheries Science Center (NEFSC) and lead author of a study on salmon foraging and the changing food web in the Northwest Atlantic published in *Marine Ecology Progress Series*. “They are like a canary in the coal mine. Dams and decreasing marine survival rates have been the primary drivers of the declines for many populations. In taking a closer look at the marine part of a salmon’s life, we found that changes in salmon diet may be a big factor.”

Atlantic salmon have a broad range, extending from the US and Portugal in the south to Canada and Russia in the north. After a freshwater phase, juveniles migrate to sea for a year or more, with North American and European salmon stocks congregating at common marine feeding areas like the waters off West Greenland during summer and fall. There, salmon feed on abundant and energy-rich prey such as capelin, a small forage fish. This diet promotes rapid growth and maturation, allowing salmon to undertake long migrations back to their natal rivers to spawn.

Changes in ocean conditions have significantly changed the quality of capelin, the primary prey for both North American and European origin Atlantic salmon feeding at West Greenland. Since the early 1970s, the North American portion of the stock complex at West Greenland has declined approximately 54 percent, and similar declines have been documented for the European stock complexes.

During the early 1990s ecosystem conditions changed across the Northwest Atlantic, including the waters off West Greenland. Shelf waters freshened and stratified, altering the annual seasonal distribution and abundance of phytoplankton and zooplankton. This ‘regime shift’, as scientists call it, affected organisms from the bottom to the top of the food web. Changes in what small planktonic organisms ate cascaded up through the food web, affecting

the quality of food available to larger forage species like capelin and ultimately many other marine mammal, sea bird and larger fish species that depend on them as prey.

To understand these food web changes, researchers examined historical stomach content data, collected before the regime shift in the 1990s, and contemporary data from the contents of approximately 1,500 salmon stomach samples collected between 2006 and 2011. Both the historical and contemporary samples were collected during the commercial fishery that occurs annually off the West Greenland coast.

Results showed Atlantic salmon ate prey that varied in both type and size. Capelin and macro-zooplankton (*Themisto* sp) were the most common components of the salmon diet, followed by boreoatlantic armhook squid, sandlance and other miscellaneous fishes. Renkawitz noted that there was a distinct absence of armhook squid in the historical data and that today salmon are eating fewer capelin and more macro-zooplankton. Research suggests that Northwest Atlantic capelin are distributed differently and are physically smaller, in addition to being less nutritious prey than they were 40 years ago.

“The reduced energy density of capelin, by almost 34 percent, is likely influencing survival and productivity of eventual Atlantic salmon spawners,” Renkawitz said. “Salmon may be experiencing an energy deficit and they may not be accumulating the energy reserves they need to survive, mature and migrate long distances back to their natal rivers to spawn. This may be one reason why we have seen large decreases in marine survival for this species across large portions of its native range over the past 40 years.”

Other studies have suggested that changes in capelin energy density and dynamics may also be partially responsible for the documented declines in the breeding success of various seabird species, growth and reproductive potential of Northwest Atlantic cod populations, and the decreasing condition of harp seals, which has also been implicated in the declining condition of polar bears.

All of these species rely either directly or indirectly on capelin as their primary energy source. Capelin, and similar forage fishes like Atlantic herring, provide an essential ecological function by transferring energy from lower trophic levels to higher trophic levels, like Atlantic salmon.

“Atlantic salmon are a great indicator of large-scale changes in the North Atlantic because they integrate components of the ecosystem over a wide geographic range and their populations are closely monitored through international stock assessment efforts,” said Tim Sheehan, a salmon researcher at the NEFSC and study co-author. “Identifying and understanding the mechanisms that cause changes in the food web may have implications for managing and rebuilding protected populations of Atlantic salmon. Results such as these can also help inform the dynamics of other commercial and recreational fisheries globally and will hopefully result in better management towards long-term sustainable use.”

The research team on this study comprised scientists from NOAA’s Northeast Fisheries Science Center in Woods Hole, Mass.; the University of Waterloo in Ontario, Canada; and the Greenland Institute of Natural Resources in Nuuk, Greenland.

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